If Sport Fishing
Is Important To Your Life
Or To Your Business
You've Got A Problem

ACID RAIN

Canada

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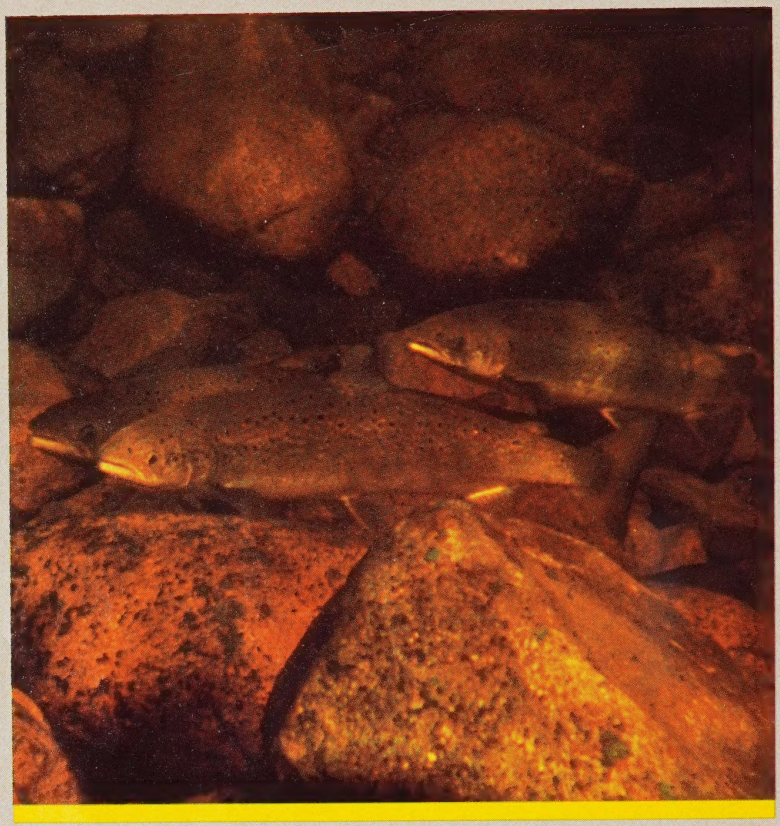
Acid rain is everyone's problem. It affects lakes, rivers, forests, buildings and — many researchers believe — human health. For people with a personal or business stake in fishing, the problem is urgent and immediate.

ACID RAIN



If you're an angler you should know that hundreds of sportfishing lakes and some rivers in Canada and the United States have already lost their fish and that there is scientific evidence that thousands more are endangered.

If you're a commercial fisherman you should be aware of the loss of valuable Atlantic salmon runs in Nova Scotia and the loss of freshwater stocks elsewhere.

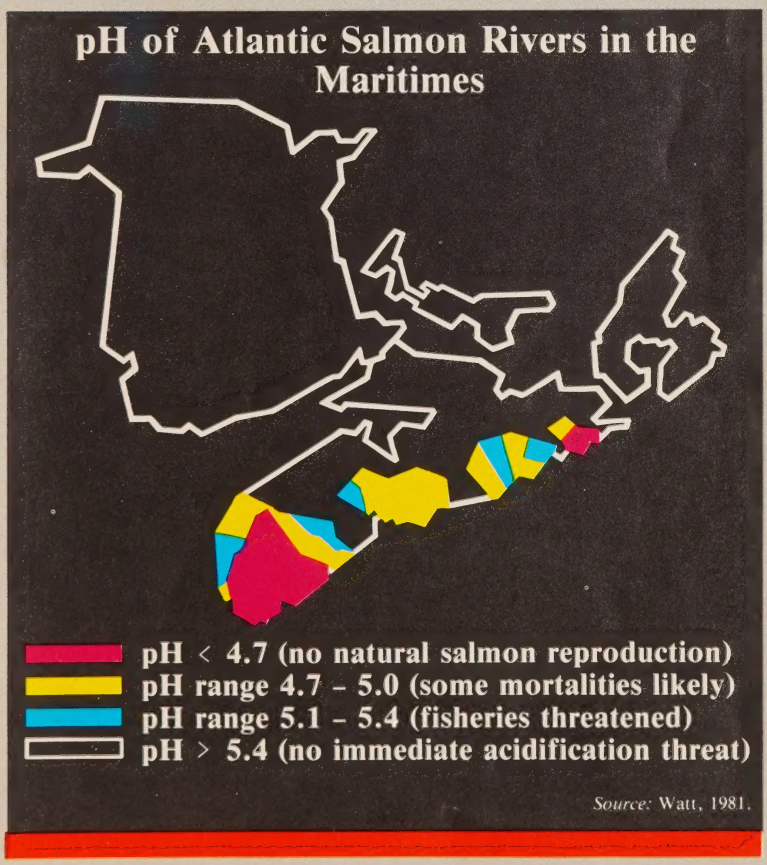
If you're a cottage owner in a popular sportfishing area, you face possible severe losses in property values as fish disappear.

If you're involved with some part of the sportfishing industry — marinas, tackle stores, tourist lodges, guiding or other services — you should know that hundreds of these businesses could collapse if acid rain continues.

These dangers are not theoretical. Although many adverse consequences of acid rain are only now being discovered, effects on fish are thoroughly documented. Scientists began studies of acid rain's effects on Scandinavian fisheries in the 1950s. In the same period Canadian scientists were studying acid rain in the Halifax, Nova Scotia and Sudbury, Ontario areas. Intensified research has been going forward in both Canada and the United States since the early 1970s.

These facts have been conclusively proven:

- Over a period of years acid rain wipes out fish populations, not in every lake and river on which it falls, but in those which, because of local geology and other characteristics, are sensitive to acid rain.
- Tens of thousands of North America's most valuable sportfishing lakes and rivers have these characteristics. They are risk areas and they are receiving acid rain.



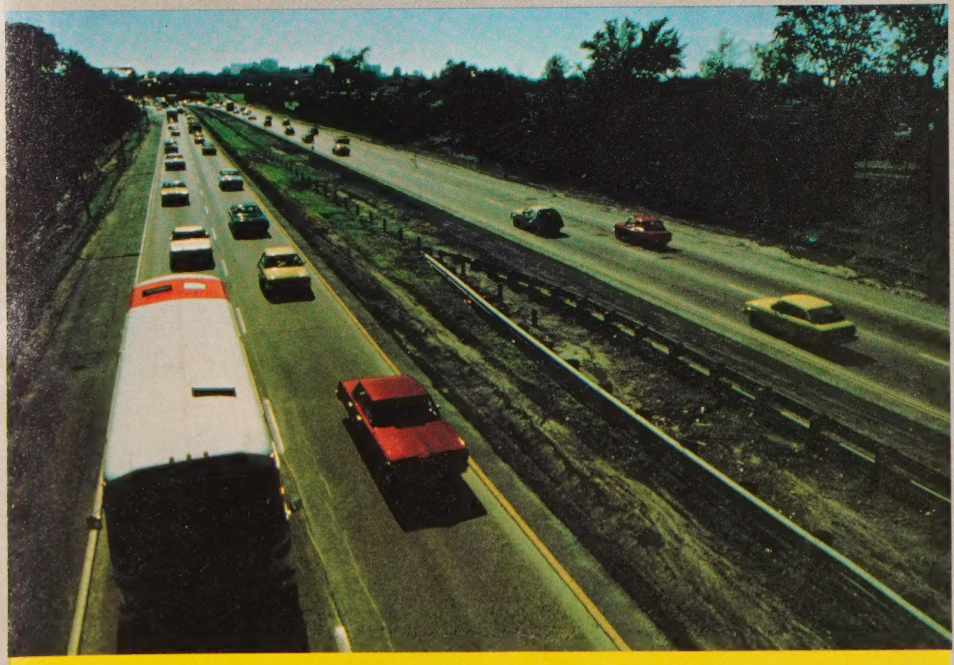
Where It Comes From

Although all rain contains some acid, "acid rain", as the term is understood today, contains much higher concentrations than normal. The excess acid in the rain is the result of man-made pollution caused primarily by the discharge of oxides of sulfur and nitrogen (i.e. SO_2 and NO_2) into the atmosphere with the burning of coal and oil by electric utilities, in the operation of plants which smelt nickel and other metal ores, and by transportation. In the atmosphere these gases combine with water vapor to form sulfuric acid (similar to the substance in car batteries) and nitric acid. These pollutants are carried hundreds and even thousands of kilometres, crossing state, provincial and international boundaries, and return to earth with rain, snow, fog and even as dry particles.

In fact, the United States National Commission on Air Quality in a 1981 report described acid rain as both an interstate and international problem. Scientists estimate that almost 60 million tons of man-made sulfuric and nitric acid are released into the atmosphere annually in North America, with 52 million tons originating in the United States and nearly eight million tons in Canada. The United States discharges 30 million tons of sulfuric acid a year, much of it from the tall smokestacks of electrical power generating plants in

the northeastern states and the upper Ohio Valley. In Canada, the main sulfuric acid sources are non-ferrous smelters and power generation. On both sides of the border, cars and trucks make up the biggest single source of nitric acid (about 40 per cent of the total), while power generating plants and industrial, commercial and residential fuel combustion together contribute most of the rest.

Researchers estimate about 50 per cent of the acid rain affecting Canada originates in the United States and 50 per cent originates in Canada. Areas in the U.S. northeast, such as the Adirondack Region, receive about 15 to 25 per cent of their acid rain from Canada.



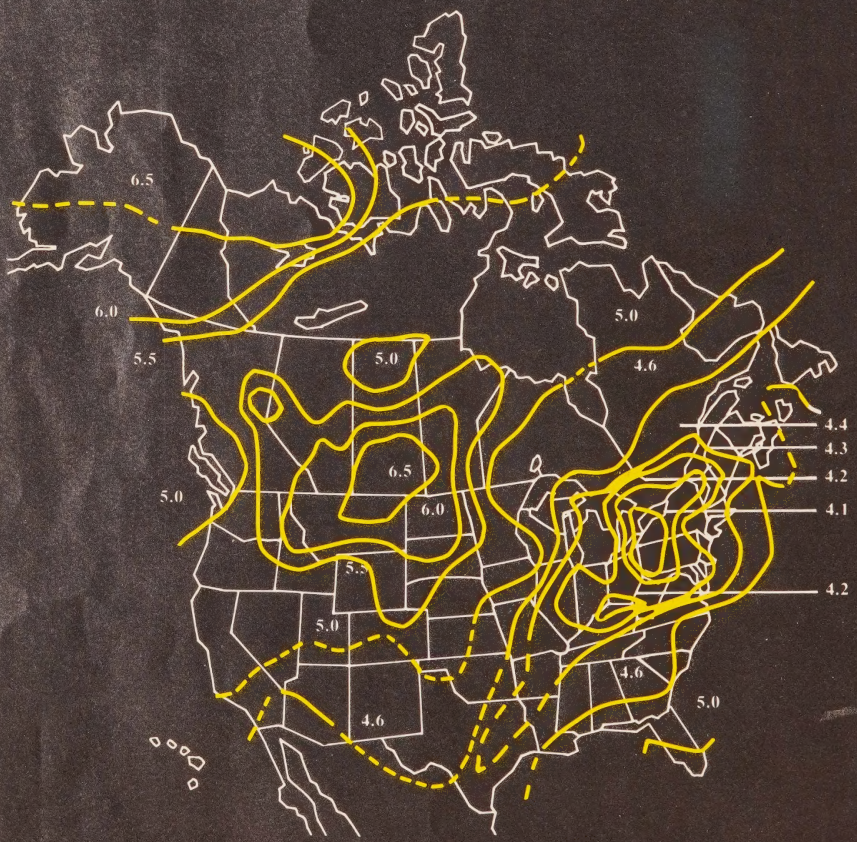
Deadly to Fish

Biologists studying the effects of acid rain on fish have found that different species are harmed in different ways and at different levels of acidification. These levels are measured in terms of pH values — the lower the pH value, the more acid in the water.

On the pH scale of 1 to 14, a reading of 1 indicates a solution is very acidic (battery acid), a pH of 5.6 is "pure" or unpolluted rain, while a pH of 13 indicates a very alkaline solution (lye). Acid rain has pH readings of 5.5 or less.

The scale, however, is deceptive to the layman. It is logarithmic, which means that pH 4 is 10 times more acidic than pH 5 and 100 times more acidic than pH 6. For most fish,

Weighted Mean pH of Precipitation, Annual Average 1979



Dashed lines indicate where data are sparse and thus only the general pattern is indicated.

Source: Gibson, 1981 (from United States-Canada, M.O.I., Work Group 1, 1981).

trouble begins at pH 5 and becomes critical at pH 4.7 and below. As acidification gets worse it affects fish in the following ways:

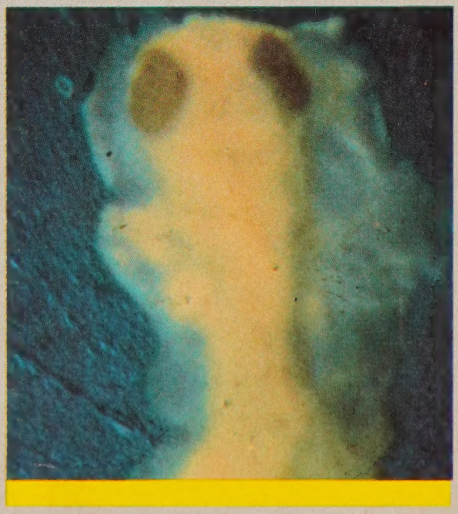
• By attacking their reproductive systems and by killing or deforming fry (which are even more vulnerable than eggs). Researchers have found that these forms of damage are the most common cause of the total extinction of stocks, and they occur *before* acid levels reach a point dangerous to adult fish. In less severe cases, although the whole fish stock may not disappear, entire age groups may be lost.

• By interfering with food chains. Some scientists believe the process can start at the very bottom of the food chain with the destruction of the tiny life forms on which minnows and other small freshwater food organisms feed before they themselves are eaten by larger fish. Seldom do fish starve as a result, but they may be forced into feeding on different species, if they are available, which further disrupts the food chain.

• Possible decalcifying and weakening of the bones of fish. When this happens, as it may in cases of extreme acidification, fish skeletons weaken while muscles remain firm. The bodies of the fish become twisted and in some cases fish lose the ability to swim.

• Metal poisoning. Investigators studying rivers and lakes subjected to acid rain have found fish kills in waters where pH levels seem to be still safe. Research has shown why: the lowered pH dissolves aluminum and other metals allowing them to mix into the water. Even in small concentrations these metals can harm and even kill fish. Certain forms of aluminum, for instance, clog gills, causing fish to suffocate.

• Below pH 5.7 some species — and below 4.7 nearly all species — can be directly injured or killed by acidification. Researchers have found that acid in the water alters body chemistry, impairs oxygen circulation, attacks gills and interferes with heart action.



High Risk Areas

Whether acid rain is an immediate threat to fish depends primarily on the geological characteristics of the area. Lakes and rivers set in land rich in limestone and other natural acid-neutralizers are not in immediate danger, and may never be. In areas lacking these natural defences, acidification is progressive. Over a period of time, acid rain causes the natural buffers in water bodies to be used up. The rapidity with which this happens increases with the acid content of the rain. The result is a decline in the pH levels of receiving waters.

Lakes and rivers can also have their pH lowered abruptly for short periods — for example when acid-laden snow melts and runs into the water, or when large volumes of water run into lakes and streams after heavy rains. The most vulnerable lakes and rivers are those which:

- are located in terrain which lacks natural buffers against acidification.
- have small watersheds (i.e. the area of land surrounding the water is small — for instance in narrow valleys).
- are located in areas receiving highly acidic precipitation.

Fisheries experts estimate that hundreds of thousands of lakes, rivers and streams in Canada and the United States match this description and are therefore potentially sensitive to acidification.

Acid Targets

The acidification of water bodies from acid rain is a progressive problem. In some parts of North America the problem is far advanced; in some it is in its early stages; in others it is a dangerous possibility.

Today's major problem areas include:

Nova Scotia In the northern part of the province, lakes and rivers are well-buffered and scientists believe that in this area they are in no immediate danger. In the poorly-buffered southern and western parts of the province the situation is different. Here, Canada's Department of Fisheries and Oceans scientists have documented the loss of Atlantic salmon runs as a result of acid rain in a number of rivers. By mid-1981 the casualty list looked like this:

- Nine rivers at pH 5.3 to 5.1. This, biologists say, is the crossover point from safety to danger for Atlantic salmon.
- Thirteen rivers cross the danger line with pH readings from 5.0 to 4.7. From hatchery tests, researchers know that at the least-acid end of this range, three out of ten salmon fry do not survive. At the other end, whole stocks are on the brink of extinction.
- Eight rivers with readings of pH 4.7 and below, believed to be now completely empty of salmon. Fisheries officials say this group includes some rivers for which sportfishing catch records go back as far as a century. Some of these rivers were important salmon producers before the first declines began in the 1950s. By 1980, scientists could find no sign of salmon reproduction in any of this group.

Regions of North America Containing Lakes and Rivers Sensitive To Acidification

Source: Modified from the Canada/United States Memorandum of Intent on Transboundary Air Pollution on Impact Assessment. Final Report January 1983.

Ontario Provincial government officials estimate that 48,000 lakes are sensitive to acid rain because of poor buffering and because they are receiving highly acidified rain and snow. Included on the danger list are 18,000 lakes in the Muskoka-Haliburton region, one the the most popular sportfishing areas in North America. Scientists have found almost 300 lakes which have either lost their fish or are classified already as "extremely sensitive" and are reaching the danger point. The evidence suggests the rain is becoming more acidic in Ontario. South of the 50th parallel, the average pH of rain in the province is now less than 5.0. In some areas averages of 4.5 to 4.2 have been noted.

Quebec and Labrador The precise degree of acidification of lakes and rivers in Quebec and the Labrador area of Newfoundland is still being documented. But scientists say that lake chemistry and wind patterns in these areas make it likely that future acid rain effects could be severe. In fact, the area may be more sensitive than Ontario. When the glaciers retreated across the region they removed buffering material from Quebec and Labrador and deposited it further south. Nearly all of Quebec's surface waters are believed to be highly sensitive to acidification. Monitoring of Laurentides Park, with its 2,500 lakes, has shown that rainfall in the area is consistently acidic.

Newfoundland and New Brunswick As in Quebec, the extent of the acid rain problem is still being documented, but large areas containing important sportfishing areas in both provinces are known to be sensitive.

America's Acid Rain Problem

Much of the continental United States (see map) is senstive to acid rain. A 1979 study by the United States' Environmental Protection Agency (EPA) showed "evidence of the spread of acid precipitation from the northeast to all the states of the Mississippi River". Other research shows the problem is spreading and intensifying in the southeastern states.

New York State In the popular Adirondack Mountains' sportfishing area, the average pH of rainfall has been running at 4.1. In 1976, Cornell University Researcher Carl Schofield measured both pH levels and fish populations in 217 Adirondack lakes 600 metres above sea level. Half had a pH below 5.0 and 90 per cent contained no fish. Later investigations by state researchers included lakes lower than 600 metres above sea level, and in these, pH values ranged from 7 to 4.8. Sampling fish populations in three lakes at the most acid end of this range, the researchers could net only one fish — a brook trout. A recent state inventory has found that nearly 11,000 acres of Adirondack waters have reached "a critical state

of acidification". State officials estimate that 22,000 pounds of sport-fishing catch is being lost annually as a result of acid rain.

Similarly, northern areas of **Minnesota, Wisconsin** and **Michigan** all have soils naturally low in buffering materials, making their lakes sensitive to acid rain. EPA estimates that some 2,600 Wisconsin lakes have pH levels at or below 6, with little or no buffering remaining. Half of the Boundary Waters Canoe Area lakes are also susceptible to acidification due to low buffering.

Tests of snowfall in upper Michigan made in the winter of 1977-78 produced average pH values of 3.5. Scientists believe the acid is being generated in a belt of industrial centers reaching from the Toronto-Buffalo area to Chicago.

In **Pennsylvania,** EPA scientists checking records going back eight years found falling pH levels in one of three of a sample group of streams. Other studies show the average pH of rain and snow to be less than 4.3. Many former trout streams have been emptied not only of the acid-sensitive rainbow trout species, but of the more resistant brook trout. In a 1980 report, EPA scientists say "circumstantial evidence shows damage to Pensylvania streams may be the result of acid precipitation".

Further south, majestic Great Smoky Mountains National Park straddles the state line separating **Tennessee** and **North Carolina.** Oldtimers can remember good brook trout fishing along some 425 miles of park streams. Today brook trout are found along only 125 miles.

National Park Service officials have found that the pH levels of rain and snow in the park are usually 4.5 and have noted a fall in the pH levels of streams since 1973. A report by NPS officials says "the impact of acid rain may threaten the existence of brook trout in the park".

In **Florida,** studies by a statewide monitoring network show highly acidic rain falling across two-thirds of the peninsula and all of the panhandle. Only south of Lake Okeechobee and along the coast do pH values rise above 5.0. Comparing these levels with those measured in studies made in the 1950s, researchers find a sharp increase in the acidity of Florida rain. With coal-burning by power generating plants scheduled to increase 250 per cent in the next decade, they expect Florida's rain to become even more acidic.

In **California, Oregon** and **Washington,** as in Canada's Pacific Coast region, the picture on acid rain is just beginning to emerge. University of California scientists, monitoring rainfall in the San Francisco Bay area and other locations as far east as Lake Tahoe, found pH values below 5.6 at all sites. One sample, taken in a storm at San José, measured 3.7. Other tests in the Sierra Nevada showed pH values from 7.6 to 5.8 in the foothills, and lower values at greater altitudes.

It's Costing Us

In the competition for tourist dollars, sportfishing is a major attraction for many regions of Canada and the United States. In Canada, federal government surveys show that sportfishing contributed $2 billion to the Canadian economy in 1980. Anglers spent $945 million in pursuit of their pastime. In Nova Scotia alone, more than $18 million was spent by anglers fishing for Atlantic salmon.

Sportfishing is an important source of income in many parts of the United States. In 1975, the U.S. Department of the Interior conducted a nationwide survey that showed 54 million Americans were anglers. These people, 70 per cent of them city dwellers, spent an average of $285 on sportfishing for a national total of $15.2 billion during the year.

Fighting Acid Rain

How do we fight acid rain? Measures fall into two main categories: holding actions which can only buy time for key fish stocks, and action to end acid rain itself. The options include:

Mitigation In the same way that bicarbonate of soda neutralizes stomach acid, large amounts of slaked lime or other neutralizers can cancel out acid inputs into lakes and rivers. Liming has been used in Sweden with limited success and researchers are testing the process in Canada and the United States. Too costly to apply to all stricken areas, particularly in the wilderness, liming cannot in any case bring back dead lakes. It may prevent some lakes and rivers from becoming acid, allowing us time to save selected fish stocks until pollution controls can put a cap on acid rain sources. Its side effects on the environment are not yet known and at best it is an interim measure.

Stopping it where it starts This is the only answer and it is a feasible one. Coal and oil burning does **not** have to result in the generation of acid rain. With the right emission controls installed, these fuels can be burned cleanly. The control systems for doing this are expensive but not prohibitive. The systems have already been developed and need only be put to use.

Understanding the Danger

We urgently need to fill gaps in our knowledge about the less direct effects of acid rain. Says Dr. David Schindler of Canada's Department of Fisheries and Oceans' Freshwater Institute: "One urgent need is for a national inventory to assess damage already done. We also need studies of how acids react with other airborne pollutants such as cadmium, zinc and mercury. These could combine to produce more serious impacts than the acid itself".

Dr. Walton Watt, another leading DFO investigator of the acid rain problem, says that its impact on Canadian fisheries has been badly underestimated. Dr. Watt says: "It now appears that widespread damage to freshwater species in Canada and the northern United States is inevitable within the next five to 20 years".

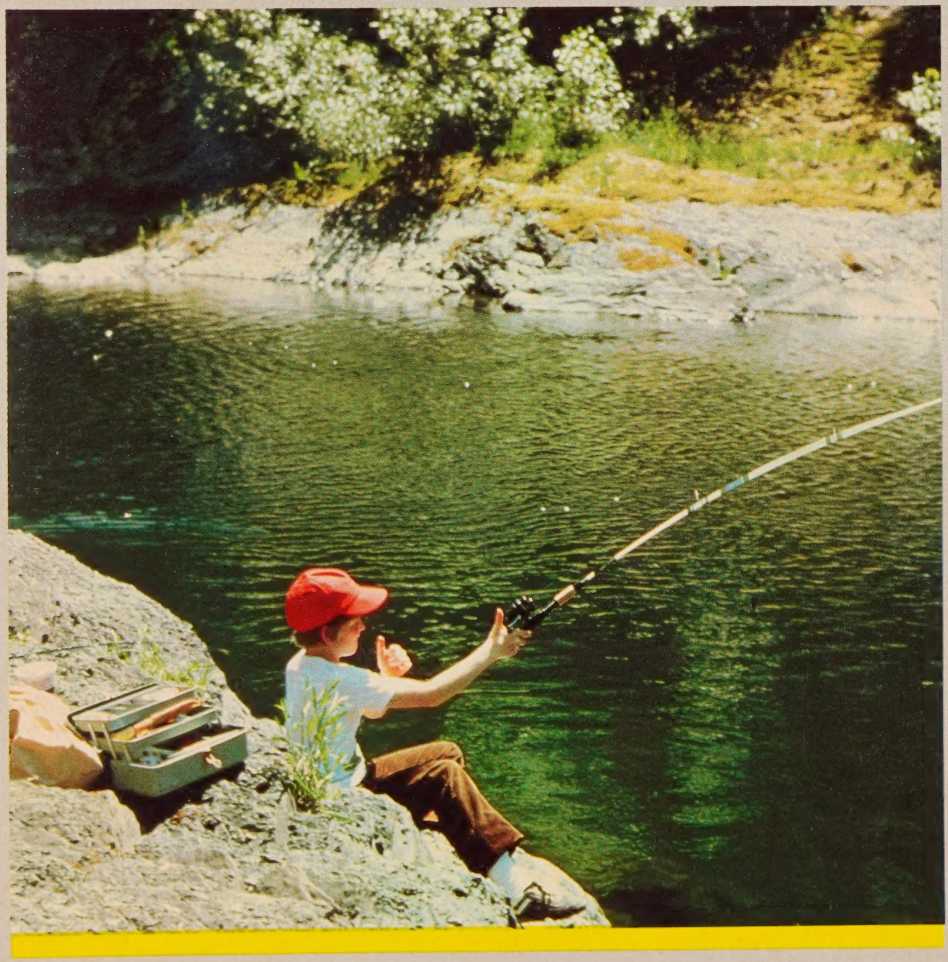
The Bottom Line

Recently the prestigious United States National Academy of Sciences noted that acid rain "is causing widespread damage to aquatic ecosystems" to such an extent that "several important species of fish and invertebrates have been eliminated over substantial parts of their natural ranges". They conclude that "the control of emissions of sulfur and nitrogen oxides from fossil fuels is necessary to halt the acidification of sensitive aquatic ecosystems", and that "the picture is disturbing enough to merit prompt tightening of restrictions on atmospheric emissions . . ." "In the long run, only the decreased reliance on fossil fuels, or improved control of a wide spectrum of pollutants can reduce the risk that our descendants will suffer food shortages, impaired health, and a damaged environment".

Yes — Something Can Be Done

Acid rain is a North American problem and can only be resolved if we work together to ensure cooperation between federal, state and provincial governments. Action by one government alone is not sufficient. We must find the political will to control the emissions of sulphur and nitrogen oxides at their source — the only effective way to resolve the problem. We have the technological capability to control these pollutants. It will be expensive but the consequences for the environment are incalculable compared to the cost of control.

Would you rather pay a little now or a lot later?



Additional Reading

Fisheries Related:

- "I Wonder Where the Fishes Went?" Harold H. Harvey. *World Record Game Fishes,* 1981.
- "Acid Rain and Fish — The Evidence Mounts". Ron Baynes. *International Angler,* Vol. 43, No. 5, March 1981.
- "Acid Rain and Atlantic Salmon". Department of Fisheries and Oceans, Resource Branch. *Nova Scotia Conservation,* Vol. 5, No. 1, March 1981.
- "And No Fish Swam: Acid Rain in Canada". Murray Johnson. *Queens Quarterly* 88/3, Autumn 1981.

General:

- *Downwind: The Acid Rain Story.* Environment Canada, Information Directorate, 1981.
- *The Case Against the Rain.* Ontario Ministry of the Environment, October 1980.
- *Still Waters: The Chilling Reality of Acid Rain.* Report of the Sub-committee on Acid Rain of the Standing Committee on Fisheries and Forestry, 1981.
- *Research Summary: Acid Rain.* United States Environmental Protection Agency. Office of Research and Development. EPA-600/8-79-028, October 1979.

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